ARTIFICIAL INTELLIGENCE AND ART EDUCATION

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Artificial intelligence belongs to that class of disciplines in which the primary focus is placed on the creation of formal proceedures, (ie. complex algorithms), which are inspired by and based on hypothetical models of the functioning of human intelligence. In this it shares something fundamental with artistic disciplines which look to nature, in the broadest sense, for stimulation and guidance.

Answering the question, "Can a system, the performance of which is based on the complex interactions of a limited set of well defined rules, successfully imitate, or even duplicate, the poorly understood intricacies of human functioning?", is neither important to this point of view nor possible to answer at the present time. By devoting itself to this question, however, the work of artificial intelligence has produced a fallout of significant tools, in the form of powerful algorithms. Furthermore, considerable conceptual and theoretical stimulation as well as solutions to many practical control problems have resulted from attempting to model human cognition, perception, proprioception, information processing, reasoning, knowledge and belief systems from a particularly well defined, albeit limited, point of view. Many of the great achievements of mankind have arisen from the toil of attempting to achieve

the unachievable. Great discoveries have occured during the pursuit of goals which, only in retrospect, could be seen to have been based on thoroughly erroneous assumptions of facts.

P.H. Winston states, "The central goals of Artificial Intelligence are to make computers more useful and to understand the principles which make intelligence possible", (1).

Artificial intelligence is a metaphorical science. Rather than being one discipline it is really a geography of interacting disciplines. These include, programming, micro-electronics, cognitive psychology, physiological psychology, pattern recognition, perception, self-organizing systems, games, music, visual arts, robots, theorem proving, semantics, knowledge and belief systems, theories of natural language and experimental aesthetics, to name a few. Consequently, it is a field of rich diversity, stimulating use of analogies in thinking about thinking, inviting experimentation, and requiring precision in specifying models and theories which are bound to the requirements of a given task, (1). Yet an underlying unity of AI work is pointed out by Z.W. Pylyshyn, et. al., "While there are a growing number of important engineering achievements and an accumulating body of techniques and tools, there is also a growing awareness of theoretical unity underlying the great diversity of research in artificial intelligence. This awareness stems from the recognition of fundamental and recurring themes in AI work: the organization and representation of knowledge, and the design of control structures for transforming this knowledge and bringing it [illegible]r on performance", (2).

Computers are sometimes considered to be models of the brain. From a hardware point of view this is a fallacy. Computers are sequential process machines, while the brain carries out its functions with massive parallel processing. Consequently, computers are very good at implementing relational algebras and at performing high precision calculations with tremendous speed. Computers are very poor, however, at making conclusions with "common sense" generality since the rules for general inference by which they operate build up imitations of "common sense" with atomistic primitives. Therefore, problems which to a brain seem trivial may require so many millions of operations for a computer to perform that the time required to arrive at a conclusion becomes staggering. Brains, on the other hand, are very good at what might be called, resonant pattern matching. They can achieve high degrees of generality in conclusions and observations with ease and relatively high speed. However, brains are extremely poor and slow, by comparison with computers, at processes requiring many iterations of high-precision operations or extensive manipulations of detailed configurations of data or calculations.

One of the prime advantages of brains, as H.L. Dreyfus points out, (3), is that they are connected to bodies which are capable of highly intricate proprioceptive manipulations, contain localized intelligences as functional subsystems, and are capable of high degrees of adaptation and learning. In addition, the functional atomic unit of neural information processing, the individual neuron, is itself a rather sophisticated, hybrid (digital-analog) computing element and is capable of its own kind of adaptation and learning.

The brain has billions of these to work with.

E.W. Kent refers to both the cross-fertilization of disciplines and conceptual differences when he states, "Cognitive psychology has already had some influence on computer programs that display some aspect of intelligence, and computer science has probably had an even greater impact on theories of cognitive psychology; however, considerations of brain hardware have had virtually no influence on either artificial intelligence programming or computer design. This is in part because of the belief that the function of the program is independent of the machine hardware, as in a universal Turing machine. This is certainly true, but it is also true that some machine designs may be much more efficient at some kinds of problems than are others", (4).

Nevertheless, it can be said with considerable certainty now that those manifestations in information and communication technology which best serve human needs and are responsible for breakthroughs or great strides most often take their design inspiration from natural models, especially the nervous system.

We are, no doubt, witnessing this again; for, as Pylyshyn, et. al. continue, "If it turns out to be the case that the diversity of manifestations of "intelligent" tasks masks a basic, underlying, technical unity and if the techniques that are just beginning to be studied are as general as some believe them to be, then the field of artificial intelligence may become the branch of computer science that will produce the most far-reaching impact on science and society"; (2).

Technology is a field of activity, the purpose of which, in its purest sense, is to extend human facility. Extending human facility requires analysis of human functioning. Artificial intelligence with modern computers represents extension (not duplication) of the mind, resulting from analysis of the mind. As such, it represents a modern manifestation of a fundamental species trait of Homo Sapiens, self-analysis. It happens that the Homo Faciens ("man the producer") side of modern man can use information resulting from self-analysis as inspiration for design strategies and creative directions -- for modeling, (replication and extension), and for evolving, (adaptation and optimization). Artificially intelligent computers are an extension of Homo Sapiens which requires Homo Faciens to supply its motivation. Homo Sapiens is fundamentally concerned with differences and relations. Computers arose from a notion that the physical medium of switches could represent the transformations of information which occure in abstract, formal, mental disciplines, like propositional calculus and relational algebra, which also concern themselves with differences and relations. Ultimately, the interface of this activity with the physical world demands the definition by Homo Faciens of a material realm, the transformations of which are available to the senses, in which to create observable symbolic representations of activity produced by activating the dynamic capabilities of abstract models.

As has been the case throughout history, artists are again present in the forefront of these new technological and theoretical developments. Examples include the modeling of compositional processes, explorations in the generative aspects of artistic language forms, and the

design and use of programmable systems in communications media. The overworked phrase, "art and technology", tends now to obscure our understanding because of its all too frequent association with mere kinetic gadgetry to charm the galleries or scientific patterns and motifs to bemuse the concert halls. In a similar way the term "new music" now obscures that which is truly experimental in that art form. As argued in an earlier paper, (5), let's adopt a new parlance and speak of the <u>extension of human facility as an art form</u>. Since the modeling of the mind is an activity which includes both subjective and objective points of view, the activity itself can be considered a medium imbued with tremendous expressive power. Hopefully, this can lead to the cooperative linking of minds in the nervous system of a unitary organism, man on earth; a linking of individual integrities which may be necessary for planetary survival.

Examples of applications of artificial intelligence in the arts from the author's work include the development of electronic music instruments designed for live performance in which can reside software models of what would normally be considered compositional or pre-compositional processes. These can then be activated with improvisational flexibility and real-time facility, (6). In addition, studies of the electrophysiological correlates of selective attention in music and the perception of structure have helped in the development of musical language models, (7) (8). The combination of these methods in a biofeedback model results in their automatic refinement through practice, (9).

Applications from other media abound and are too numerous to list here.

Today's students of communication media arts must be general systems thinkers, capable of translating ideas from medium to medium with improvisational flexibility, skilled efficiency, and without predisposition to set ideas or materials. We cannot provide them all the practical knowledge in all the arts disciplines during their short stay in our institutions. We can, however, seek to enhance their abilities to conceive and understand systems with which they may be confronted by applying the basic principles of organization, fundamental to distributed control intelligences in devices and perceptual and affective factors at work in creating effects.

It should be noted, especially in the economic climate of ultimate practicality, that there is a critical distinction made here between what is commonly known in educational circles as "pre-professional training" and general systems approaches. Both are aimed at producing "professionalism". The first, however, is directed at gaining familiarity with existing systems and equipment; the latter focuses on tools of understanding. It is argued that the latter is ultimately more valuable with long lasting significance. An approach to training which emphasizes "this knob does this and this knob does that" guaranties that the acquired knowledge will be obsolete in a few short years. Instead we could examine the <u>idea</u> of the knob and analyze its efficacy as a human interface and control translation device. Anyone can figure out what it <u>does</u> in a given application simply by turning it.

Until recently, rapport between art and technology in the schools has come about through the employment of the Bauhaus pedagogical methods, which are characterized by product design through the use of abstract motifs. This idea of "making objects or events", either for aesthetic purposes or for use as educational or industrial prototypes, has too long dominated design and compositional thinking. The Seventies saw the introduction of the more mutable and dynamically changing forms of communications media and performance into a few educational situations. It still remains for us to realize the promise of generalized thinking in this area, however. A systems grasp of technology and its problems appears to be much more relevant to our contemporary social situation and to the vast unknowns to be explored in subjective experience.

At the San Francisco Art Institute we are now engaged in an educational experiment, . . . to attempt to teach advanced concepts from artificial intelligence to students who are not necessarily expected to have any background in computer science or formal methods. To this end the author has designed a course of study called, ARTIFICIAL INTELLIGENCE *IN THE ARTS*. The class undertakes an examination of the field of "fine arts computation" with special emphasis on the methods of artificial intelligence applicable to artistic production with communications media technology and to research in the structure of arts languages. The course includes evaluation of "intelligent" computer control systems with respect to their artistic efficacy and human interface features in such disciplines as video, graphics, music composition and analysis, kinetic arts and performance. Principles of general systems organization and design of algorithmic

processes are studied in the context of actual applications drawn from current activities in the field. To support the course a modest laboratory with small computers and a large variety of input and output devices has been set up.

Students are first presented with a picture of the "state of the art" of artificial intelligence in an attempt to stimulate them to obtain the basic skills required to play an informed role in the context of nontrivial development projects conceived of in the lab setting or the class. Forcing students to obtain high theoretical competence <u>before</u> allowing them to practice their craft has produced the embarrassing situation that amateurs are often better and more talented than graduates of our schools. We have the misconception that a steady accretion of inert knowledge is forever prerequisite to an understanding of our discipline. Our curriculum proposes to invert this process in some respects.

In order that the reader can clearly see how such a broad subject area can be structured, the course topic outline used at the San Francisco Art Institute is included here in some detail.

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ARTIFICIAL INTELLIGENCE IN THE ARTS:

COURSE TOPIC OUTLINE

(introduction to foundations and applications)

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I. What is artificial intelligence (AI)?

   A. A metaphorical science: some views of AI

      1. The exploration of intellectual processes
      2. Collections of "weak" methods
      3. Experimental psychology
      4. Extending the notion of engineering
      5. Creativity and invention - AI for AI's sake

   B. Historical view of artistic motivations for AI - artists were there from the beginning

   C. Model building - a basic discipline

      1. Motivations - task orientation
      2. Step-by-step analysis of human functions
      3. Logic, automata and algorithms
      4. The information processing view of human functions
      5. Systems of human interaction - language forms
      6. The idea of concept spaces

   D. The geography of interacting disciplines - psychology, linguistics, sociology, biology, medicine, technology, literature, music, art and experimental aesthetics

   E. Yes, but does it work - the usefulness of "incorrect" cognitive simulations

   F. The "double" concept - is it fundamental to human behavior?

II. Systems structures - information processing in the brains of men and machines

   A. The representation of information with electronic signals - some fundamentals of communications engineering

      1. Analog/digital systems, discrete/continuous processes, resolution, sensitivity, signal-to-noise ratio, channel bandwidth, noise, frequency domain, time domain, filters, discriminability threshold, modulation, detection and discrete codes (ex. binary representation)
      2. Parallel processes, serial processes, feedforward control, feedback control and pipelining

   B. Basic architecture of computers

      1. Basic logic functions and Karnaugh maps
      2. What is propositional calculus?

3. The CPU - its internal organization
4. Machine language and assemblers
5. Memory structures
6. Input/output
7. Synchronous logic
8. Handshaking
9. Bus structures
10. High level languages (ex. BASIC, PASCAL, LISP)

C. Basic architecture of the brain and its modes of operation

1. The neuron - a simple hybrid computer
2. Sensory input structures - early stages of analysis
3. Perception and higher processes
    a. examples from vision and audition
    b. place coding/frequency coding
    c. lateral inhibition
    d. selective convergence
    e. data reduction
    f. opponent process coding
4. General principals of sensory coding
    a. feature extraction
    b. multidimensionally tuned extractors
    c. degrees of certainty and goodness of fit
    d. spatial frequency
    e. position independence and recognition
    f. spectral signatures
5. Still higher, cortical processing
    a. multidimensional perceptual spaces
    b. multidimensional concept spaces
    c. multimodal analysis
6. Goal defining systems and logical functions
    a. synthesis of action plans
    b. motivation
    c. optimization
7. Electrophysiological correlates of information processing and states of consciousness
    a. transient events and evoked responses
    b. coherent events and states of consciousness
    c. mechanisms of attention

8. The output effectors - control of motion
9. Models of memory

D. Special examples from the use of biofeedback in the arts

III. Programs as entities

A. Universal Turing machines and the independence of programs

B. Basic algorithmic processes

IV. Perceptrons

V. Information Theory

A. Patterns, randomness and predictability

B. Quantization of information

C. Applications from the arts

D. Limitations of this view

VI. Pattern recognition

A. String languages and grammars

B. Pattern languages and grammars

C. Applications from the arts - data reduced language descriptions

VII. Some primary AI strategies

A. Means-end analysis - general problem solving

B. Generate and test

C. Heuristic search

D. Hill climbing

E. Match

F. Hypothesize and match

G. The concept of TOTE units

H. The idea of knowledge frames

VIII. Heuristics

A. Self-modifying, adaptive systems

B. Switchboard vs. statistical theories of learning and memory/patching vs. stochastics

IX. Applications to research and production in the arts

A. Music composition

B. Video and electronic graphics

C. Image processing, analysis and scene description

D. Image processing languages, dynamic manipulation and animation

E. Communications media production systems

1. Recording, signal processing and automated mixing
2. Production control
3. Post-processing/Post-production

F. Experimental aesthetics and research in the structure of arts languages

X. Models of thought and natural language

XI. Speculations on artistic metalanguages

XII. "What computers can't do!"